BIOCIDAL *SIDA* (MALVACEAE)

CHARLES L. BURANDT, JR.

Department of Biology, Texas A & I University
Kingsville, TX 78363, U.S.A.

ABSTRACT

The secretions of glandular trichomes of two South American species of *Sida* are highly toxic to ants and cockroaches. In natural habitat, these secretions most likely provide resistance to herbivory by insect or other small arthropods.

INTRODUCTION

During preparation of a monographic treatment of *Sida* section *Oligandrae* (Malvaceae) two species were observed with an interesting vestiture of stalked glandular trichomes (Fig. 1). One species, *Sida jatrophoides* L' Héritier, is a xerophyte occurring in scattered populations from coastal Peru and the Galapagos. The other, *Sida palmata* Cavanilles, is a mesophyte occuring along trailsides in northern Peru and southern Ecuador (Burandt 1992). Touching the young stems or petioles of either species left the skin covered with a moist but not sticky film, evidently the secretion of these trichomes.

Several observations coincided to suggest and support a hypothesis that the trichome secretions in these species might function to repel or possibly kill walking arthropods: 1. The droplets of secretions formed at the elevated tips of the trichomes (Fig. 1) would undoubtedly contact an insect walking on the plants. 2. The trichomes were more densely distributed (especially in young *S. jatrophoides*) in the inflorescence branches (Fig. 1) and in the petiole area just below the blades. A walking insect would be obliged to cross a veritable mine field of droplets to get to the presumably more delectable leaf blades and flowers. 3. Plant populations studied in the field appeared relatively free of insects, and the leaves were free of evidence of insect herbivory.

The lethality of morphologically similar glandular trichomes to arthropods has been frequently reported (Juniper and Southwood 1986). While toxic compounds may also be present in trichome secretions (Carter et al. 1989, Walters et al. 1989, Dimock and Kennedy 1983, Gerhold et al. 1984, and Williams et al. 1980), their role in pest resistance is complicated by the fact that most trichome secretions are adhesive and the principal mode of action is by trapping - larvae or adults are immobilized until they die. Conversely, the trichome secretions of *Sida* sect. *Oligandrae* are non-adhesive and any antibioses observed for the these secretions would likely be attributable to the effects of toxins alone. This study presents experimental evidence which strongly supports the hypothesis that natural toxins in the secretions in *Sida* section *Oligandrae* potentially function as deterrents to arthropod herbivory.

METHODS

Plants of *S. palmata* and *S. jatrophoides* were germinated from scarified seeds placed in 75 to 95 mm plastic pots filled with sand/clay/peat mix. Seedlings were kept in a growth chamber illuminated with fluorescent "gro-lights" and set for a 12 hr photoperiod with 17° night and 27° C day temperatures. They were supplied with deionized water and commercially available fertilizers. To encourage flowering, fertilizers were discontinued, soils were leached by excess provision of deionized water, and plants were allowed to become water-stressed. Inflorescences were well developed after six months of growth, and trials were begun.

Toxicity of the secretions of these species was assayed using fire ants (*Solenopsis invicta* L.) and German cockroaches (*Blattella germanica* Buren). Ants were collected as needed from field colonies, whereas immature cockroaches (5 – 10 mm in length excluding antennae) were gathered from a laboratory-maintained colony. Active specimens of these insects were subjected to various topical applications as described below. After treatment, test and control specimens were housed in covered 500 ml glass containers for observation.

SIDA PALMATA assay:

Trial no. 1. Fifteen ants were individually gathered with an artist's small paintbrush and repeatedly pressed against secretory trichomes of *S. palmata*. Ants were then placed collectively in a container. As a control, 15 ants were "jostled" with a clean paintbrush and placed collectively in a separate container. Mortality was recorded at 21 hrs.

Trial no. 2. Ten ants were similarly treated but placed in 10 individual containers. As a control, 10 ants were repeatedly pressed against trichome-bearing parts of a dried specimen of *S. palmata* and placed in 10 individual containers. A second control consisted of 10 otherwise unmolested ants placed in 10 individual containers. Mortality was recorded at 21 hrs.

Trial no. 3. Ten ants were individually gathered with a paintbrush and gently placed on plant parts bearing numerous secretory trichomes. If necessary, they were coaxed to walk sufficiently to come into contact with trichomes. Ants that fell were retrieved and again placed on trichome-

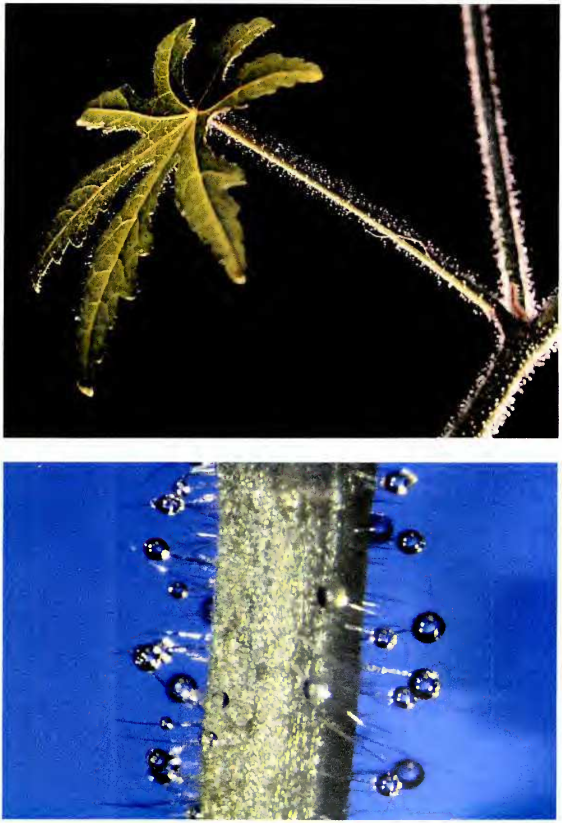

FIG. 1. Above: branches of leafy inflorescence of *S. jatrophoides*; below: petiole of *S. jatrophoides* (ca. 1.25 mm diameter).

bearing areas. Ants were then placed in 10 individual containers. As a control, 10 ants were placed individually in 10 containers and, using a clean paintbrush, swabbed with deionized water. Mortality was recorded at 7 hrs.

Trial no. 4. Twelve cockroaches were placed individually in glass containers and anesthetized with CO^2 gas. Secretions were then collected by passing an artist's small paint brush over appropriate plant surfaces until bristles were saturated. Cockroaches were then "painted" on their ventral sides with the secretions. As a control, 12 roaches were placed individually in glass containers, anesthetized with CO^2, and "painted" on their ventral sides with deionized water. Mortality was recorded at 5 hrs.

Sida jatrophoides assay:

Trial no. 1. Twenty ants (two combined trials) ants were individually gathered with a paintbrush and gently placed on plant parts bearing numerous secretory trichomes. If necessary, they were coaxed to walk sufficiently to come into contact with trichomes. Ants that fell were retrieved and again placed on trichome-bearing areas. Ants were then placed in 20 individual containers. As a control, 20 ants were placed individually in 20 containers and, using a clean paintbrush, swabbed with deionized water. Mortality was recorded at 8 hrs.

Trial no. 2. Thirteen cockroaches were individually placed in glass containers and anesthetized with CO^2 gas. Secretions were then collected by passing an artist's small paint brush over appropriate plant surfaces until bristles were saturated. Cockroaches were then "painted" on their ventral sides with the secretions. As a control, 13 roaches were placed individually in glass containers, anesthetized with CO^2, and "painted" on their ventral sides with deionized water. Mortality was recorded at 5 hrs.

Trial no. 3. Seven cockroaches were treated as in the preceding trial but "painted" on their dorsal sides with the secretions of *S. jatrophoides*. As a control, 7 roaches were treated as above but "painted" with deionized water on their dorsal sides. Mortality was recorded at 5 hrs.

RESULTS

Insect behavior

Initial responses of both roaches and ants to application of plant secretions was similar. Brief episodic whole-body convulsions and tremors occurred sporadically within the first few minutes. Individual legs became sporadically or continuously rigid and were dragged or remained variously skewed to the side or to the rear. Rarely, an appendage would disarticulate. Effective walking gradually became impossible and specimens collapsed

Table 1. Lethality of secretions of *S. palmata* and *S. jatrophoides* to ants and roaches. S = secretions applied, C = control. For each, the number dead precedes the number treated (N).

Trial Number:	1		2			3		4		Total	
	S	C	S	C	C	S	C	S	C	S	C
S. palmata											
Ants	9(15)	1(15)	9(10)	2(10)	0(10)	6(10)	0(10)	–	–	24(35)	3(45)
Roaches	–	–	–	–	–	–	–	12(12)	0(12)	12(12)	0(12)
S. jatrophoides											
Ants	19(20)	2(10)	–	–	–	–	–	–	–	19(20)	2(10)
Roaches	13(13)	0(13)	7(7)	0(7)	–	–	–	–	–	20(20)	0(20)
								Grand Totals			
									Ants	43(55)	5(55)
									Roaches	32(32)	0(32)

and could not right themselves. In ants and occasionally in roaches, these symptoms appeared to subside within 30 minutes of treatment but later returned, however, with increasing dysfunction eventually involving all appendages. A few ants appeared to completely recover.

Insect Mortality

At natural concentrations, secretions of the glandular trichomes of both *S. palmata* and *S. jatrophoides* were very lethal. Roach and ant mortality pertrial and per control(s) are summarized in table 1. Of 35 ants variously treated with secretions of *S. palmata*, 24 died whereas only 3 of 45 control ants died. All 12 roaches treated with *S. palmata* died whereas none of the 12 control roaches died. Of 20 ants treated with secretions of *S. jatrophoides*, 19 died whereas only 2 of 10 control ants died. All 20 roaches treated with secretions of *S. jatrophoides* died whereas none of the 20 control roaches died. Totaling the toxicity assays using ants, 43 of 55 of those treated with plant secretions died whereas only 5 of 55 control ants died. Totaling the toxicity assays using cockroaches, 32 of 32 treated roaches died whereas none of the 32 control roaches died.

DISCUSSIONS

All plants exhibit potential resistance to herbivory. Deterrent morphologies range from the simple mechanical resistance provided by toughened tissues to the honed injection devices of the trichomes of Urticaceae. An array of molecular defenses is also available to plants. Ordinary sap, exuded as a result of wounding, may be mildly repellent, or lethal toxins such as pyrethrins and nicotine may be produced.

Most plant structures and molecules serve several functions, however, and their roles in herbivore resistance is often subsidiary to other functions and difficult to establish. The dramatic lethality of trichome secretions of *Sida* is thus more remarkable since it appears to be due solely to the effect of toxins. That such a specialization might evolve from glandular trichomes with broader methods of antibiosis is not surprising but is, nevertheless, apparently rare or little reported. It should be interesting to survey additional taxa and assay for toxicity those which possess similar non-adhesive trichome secretions.

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